DOCUMENT RESUME

ED 383 559 SE 056 365

TITLE	An Exercise in Using the U.S. Environmental Protection Agency's Hazard Ranking System: A Simulation. Grades 8-12.
INSTITUTION	HAZWRAP, The Hazardous Waste Remedial Actions Program.
SPONS AGENCY	Department of Energy, Washington, D.C.
REPORT NO	DOE/EM-0213
PUB DATE	Oct 94
NOTE	26p.
PUB TYPE	Guides - Classroom Use - Teaching Guides (For Teacher) (052)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Data Analysis; Environmental Education; Groundwater; *Hazardous Materials; Learning Activities; Map Skills; Secondary Education; *Simulation; *Student Projects; *Waste Disposal; *Water Pollution; Worksheets
IDENTIFIERS	Environmental Protection; Environmental Protection Agency; *Risk Assessment

ABSTRACT

The educational objective of this exercise is for students to use a risk assessment tool to evaluate a hazardous release site and for students in grades 8-12 to increase their experience with geology, aquifers, soils, land use, pollution, data analysis, and map concepts. Students use background information on hazardous materials, the Environmental Protection Agency, and the Hazard Ranking System to complete a simulation activity. Students are given maps, site reports, and lab reports for a hazard release site and follow steps to assess the risk involved and give a priority ranking to the site. This teaching guide contains answers to worksheets, an introduction to the activity, background information, and instructions and worksheets needed for each step in the risk assessment. Topics related to the exercise include Earth science (geology); environmental science (pollution); mathematics (square roots, division, and formulas); and geography (map reading and natural resources). (LZ)

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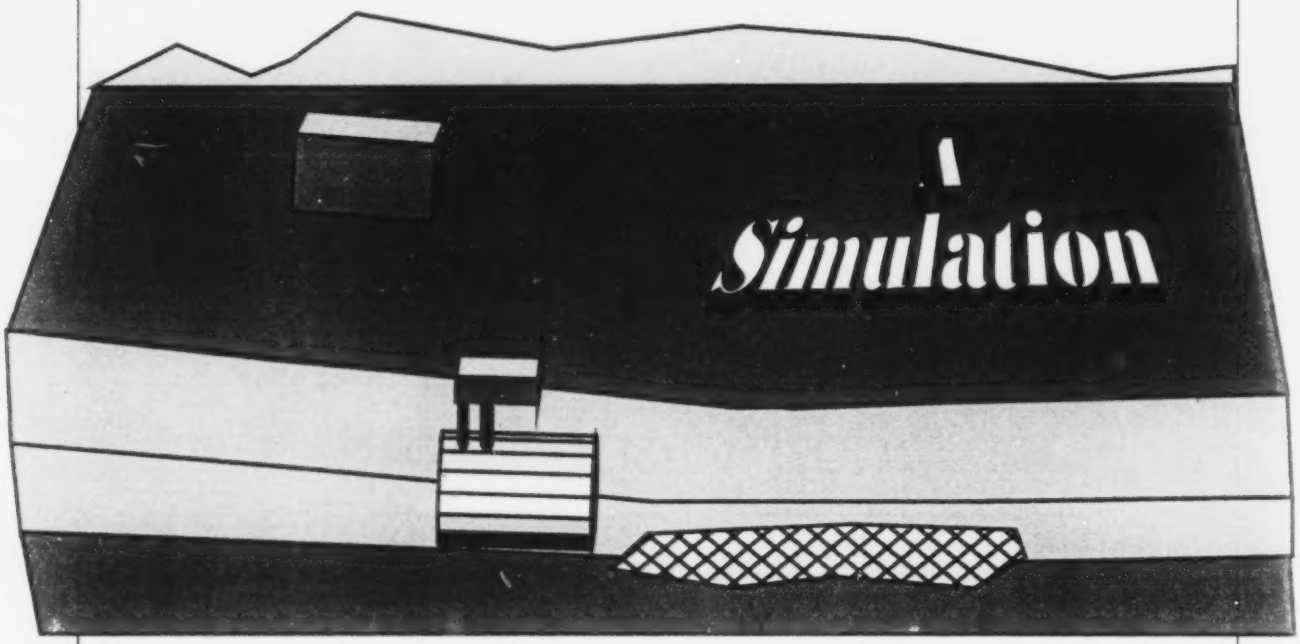
An Exercise in Using the U.S. Environmental Protection Agency's Hazard Ranking System



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Grades 8-12

October 1994

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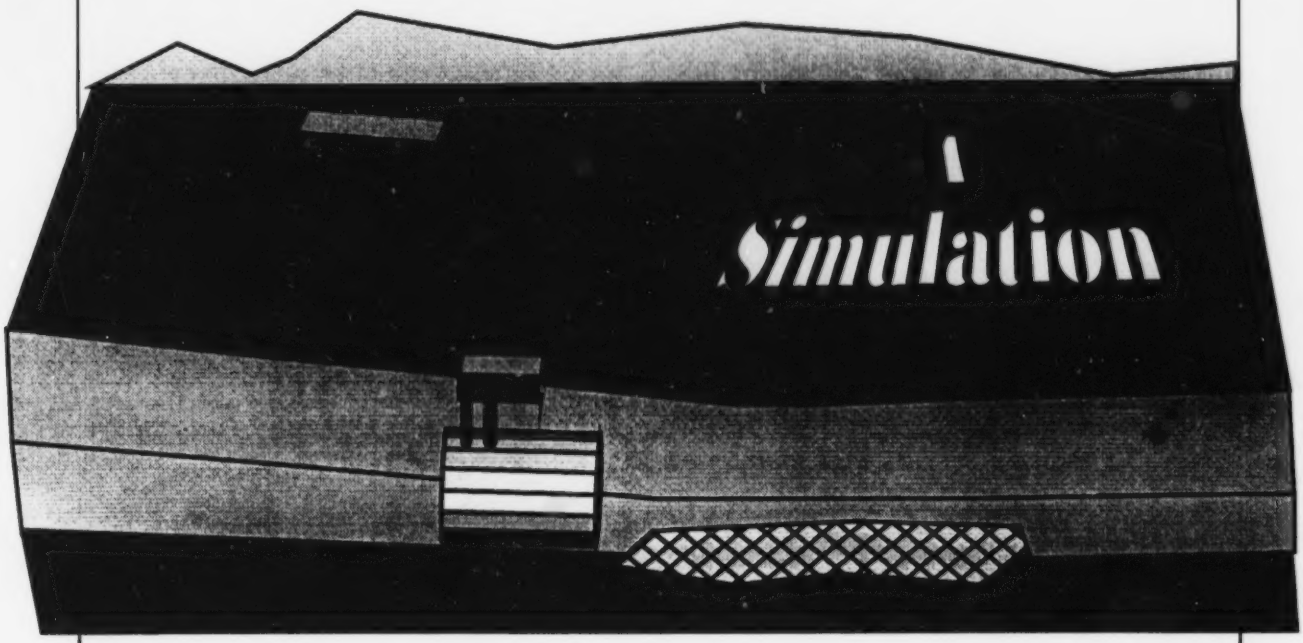


Grades 8-12

October 1994

EPA Hazard Ranking System

a Simulation

prepared at
HAZWRAP

Summer 1994

EPA Hazard Ranking System Simulation

Teacher Information

Grade Level: 8-12

Educational Objective: For students to use a risk assessment tool to evaluate a hazardous release site. For students to increase their experience with geology, aquifers, soils, land use, pollution, data analysis, and map concepts.

Description: Students use background information on hazardous materials, the Environmental Protection Agency (EPA), and the Hazard Ranking System (HRS) to complete a simulation activity. Students are given maps, site reports, and lab reports for a hazard release site. Steps are followed to assess the risk involved and give a priority ranking to the site.

Materials:

Background sheets on hazardous release areas, EPA, CERCLA, RCRA, HRS, NPL.
Scenario for the hazard release site.
Site reports, maps, and lab reports for each site.
Hazard Ranking System (HRS) procedures & worksheet
National Priority List (NPL) examples.
Calculator (if available)

Related Subject/Topics: Earth Science/geology; Environmental science/pollution;
Mathematics/square roots/division/formulas; Geography/map reading/natural resources.

Notes: The Hazard Ranking System (HRS) instructions included here are taken from the actual Code of Federal Regulations (CFR) used by EPA workers and others in the field. The HRS has been simplified for students' use, but is essentially accurate. For complete information consult CFR 40, Part 300, published by the office of the Federal Register, National Archives and Records Administration, from the U.S. Printing Office,

Superintendent of Documents
Mail Stop: SSOP
Washington, D.C. 20402

Related Material: More information related to this activity is available free for educators from the Center for Environmental Management Information

P.O. Box 23769
Washington, D.C. 20026-3769
#(800) 736-3282

Ask for: "Environmental Restoration and Waste Management (EM) Program: An Introduction" (DOE/EM-0013P)
"Committed to Results: DOE's Environmental Management Program" (DOE/EM-0152P)

For more information on hazardous material cleanup technologies, you can contact the:

Office of Technology Transfer
P.O. Box 2009
Oak Ridge, Tennessee 37831
(800) 845-2096
E-mail culverjw@ornl.gov

Teacher Instructions:

Each student or group should receive:

- 1 Background information about the EPA HRS
- 1 Scenario Information
- 1 Set of instructions for HRS worksheet
- 1 HRS worksheet (consumable)
- 1 Site report
- 1 Chemical report
- 1 National Priority List Examples

There are four different site reports provided; each student or group only needs one. When a site report is finished, a comparison of sites can be done involving the entire class. There are two different chemical reports provided; each student/group should receive only one of these reports. Of all the materials furnished, only the Hazard Ranking System worksheet is a consumable; all other materials can be reused. Copy all materials previously listed and distribute them to the students/groups.

Have the students read the background and scenario information sheets and then start on their worksheets by following the HRS instructions. Students will be working only on the groundwater section of the HRS. Other scores for the air, soil, and surface water will be provided to allow the students to calculate the overall score of their site. A list of some of hazard sites is provided to allow the students to compare each site to others.

Students will need access to a United States Map, and a calculator would be helpful.

Extensions:

You may wish to have your students do further research on the EPA or waste hazards and to write a summary report.

Answers:

Groundwater Migration Score Sheets Key

	CITY	Perry, FL	Perry, FL	Scranton, PA	Scranton, PA	Belden, ND	Belden, ND	Las Vegas, NV	Las Vegas, NV
	CHEMICAL	Phenol	Nitro	Phenol	Nitro	Phenol	Nitro	Phenol	Nitro
FACTOR									
1	.....	0	0	0	0	0	0	0	0
2a	.....	10	10	10	10	10	10	10	10
2b	.....	6	6	6	6	1	1	1	1
2c	.....	3	3	1	1	3	3	3	3
2d	.....	35	35	5	5	25	25	35	35
2e	.....	440	40	120	120	290	290	390	390
3	.....	440	40	120	120	290	290	390	390
4	.....	0.002	20	0.002	20	0.002	20	0.002	20
5	.....	100	100	100	100	100	100	100	100
6	.....	1	6	1	6	1	6	1	6
7	.....	9	9	18	18	9	9	9	9
8a	.....	0	0	0	0	0	0	0	0
8b	.....	0	0	0	0	0	0	0	0
8c	.....	3.9	3.9	12944.6	12944.6	3.57	3.57	12401.7	12401.7
8d	.....	3.9	3.9	12944.6	12944.6	3.57	3.57	12401.7	12401.7
9	.....	5	5	5	5	5	5	5	5
10	.....	20	20	20	20	20	207	20	20
11	.....	37.9	37.9	12987.6	12987.6	37.57	37.57	12435.7	12435.7
TOTAL		0.202	0.110	18.89	100 (113.35)	0.132	0.792	58.79	100 (352.72)

Parenthesis () indicate number answers that can't be used because they are over maximum allowed; use maximum values as stated on scoresheet

Distance Category Key

Distance Category	CITY	Perry, FL	Perry, FL	Scranton, PA	Scranton, PA	Belden, ND	Belden, ND	Las Vegas, NV	Las Vegas, NV
0 – 1/4 mi	.....	0	0	0	0	0	0	0	0
1/4-1/2 mi	.....	0	0	101213	101213	0	0	0	0
1/2 – 1 mi	.....	2	2	16684	16684	1	1	81623	81623
1 – 2 mi	.....	2	2	9385	9385	0.7	0.7	26068	26068
2 – 3 mi	.....	9	9	2122	2122	21	21	8163	8163
3 – 4 mi	.....	26	26	42	42	13	13	8163	8163
TOTAL		39	39	129446	129446	35.7	35.7	124017	124017

Final Score Key

	CITY	Perry, FL	Perry, FL	Scranton, PA	Scranton, PA	Belden, ND	Belden, ND	Las Vegas, NV	Las Vegas, NV
Soil	.....	0	0	0.02272	0.13636	0	0	0.02272	0.13636
Air	.....	0	0	0	0	0	0	0	0
Surface Water	.....	0	0	0	0	0	0	0	0
Ground Water	.....	0.212	0.110	18.89	100	0.132	0.792	58.79	100
TOTAL		0.101	0.055	9.45	50.00	0.066	0.396	29.40	50.00

EPA Hazard Ranking System

Introduction:

In this activity you will take on the role of a United States Environmental Protection Agency (EPA) field analyzer. A hazardous substance has been accidentally released somewhere in America, and your job is to assess the risk to people and resources in that area. You will use the Hazard Ranking System (HRS) that EPA workers and others use to determine the risk of sites throughout the country.

Background:

Hazardous Waste

Aapproximately six (6) million underground storage tanks containing chemicals and over 6000 landfills exist in the United States in the 1990s. Many of these sites contain hazardous materials which can chemically change, leak, and affect the surrounding land, air, and water.

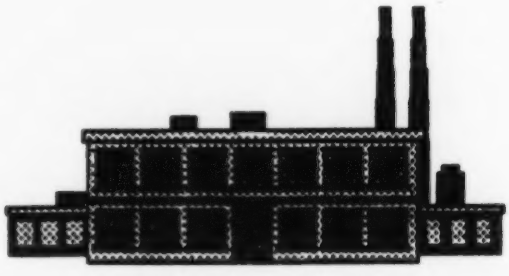
Much of the hazardous material being stored is hazardous waste resulting from industrial processes we depend on: production of consumer goods and fuels, insecticides, cleaners, solvents, drugs, etc. The definition of a hazardous waste, according to the Resource Conservation and Recovery Act (RCRA), is any waste that may cause or significantly contribute to serious illness, injury, or death, or that could damage or pollute the environment when improperly managed. Many of the problems connected with hazardous wastes occur when illegal disposal, improper treatment or storage, or spills take place.

Waste Management

In the 1980s the EPA estimated that 35 million tons or more of hazardous waste are produced annually and only 10% of it is managed acceptably. Technologies have been developed to properly manage hazardous waste, and new techniques are continually being created to deal with hazardous releases. The technologies are in demand as more hazardous waste is produced, and wastes stored in aging facilities begin to leak into the environment. For example, robotic excavation is used to dig up contaminated soil without exposing humans to dangerous materials. Bioremediation has been employed to add bacteria to hazardous materials in situ (at the site) to change dangerous chemicals to a safer form.

Risk Assessment

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as "Superfund," was established in 1980 to clean up the worst abandoned or inactive waste disposal sites. A procedure was developed to rank the risk involved at each site to determine which ones require the most immediate attention. The HRS gives each site a score from 0 to 100, and places any site with a score of over 28.5 on a National Priority List (NPL) for cleanup.



Scenario:

An old underground storage tank from a closed factory has begun leaking. This problem was detected during a routine spot check when the tank's volume had decreased. Attached find the complete lab report of the material detected, and the surveyor's site report for the area. The people living in the area are highly concerned and are depending on you to find out the extent of the risk involved with the leak. Use your data, follow the Hazard Ranking System procedures, and compute a site score for the area.

Site Score:

The site score (S) ranges from 0 to 100, according to this formula:

$$S = \sqrt{\frac{(S_{gw}^2 + S_{sw}^2 + S_s^2 + S_a^2)}{4}}$$

S_{gw}=groundwater score; S_{sw}=surface water score; S_s=soil score; and S_a=air score.

Four different analysis groups will calculate the scores for the site. Your group has the knowledge to perform the groundwater evaluation and find S_{gw}. Your score will be combined with the others to form the final site score.

Calculate Groundwater Score:

Fill in the "Groundwater Migration Pathway Scoresheet" using information from your site reports and maps.

Groundwater Score Sheet Instructions

Part I: Likelihood of Release to an Aquifer

Evaluate the chances that the contaminant has reached the groundwater in the aquifer where the spill occurred. Fill in either Step 1 ("Observed Release") or Step 2 ("Potential to Release").

Step 1 If a hazardous substance was observed entering the aquifer, write the value 550 in blank #1, and enter 0 in all blanks 2a--2e, and then go to step 3. Proceed on to Part II.

Step 2 If an observed release cannot be established, assign a value of 0 in step 1, and follow these procedures for steps 2a--2e:

2a "Containment" -- use the "Containment Factor Values" table to decide which value to assign:

TABLE: Containment Factor Values for Groundwater Migration Pathway

Source	Assigned Value
TANK	
Below-ground tank	Evaluate using all sources criteria
Evidence of hazardous substance migration from tank area	10
Tank and ancillary equipment not provided with secondary containment (e.g., liner, vault system, double wall, cement cover)	10
No diking (or no similar structure) surrounding tank	10
No evidence of hazardous substance migration from tank area, tank and equipment surrounded by sound diking that is regularly inspected and maintained	10
(a) tank provided with secondary containment	9
(b) tank equipment provided with secondary containment with leak detection and collection system	7
(c) tank and equipment provided with secondary containment system that detects and collects spilled or leaked substances, and groundwater monitoring	5
(d) containment system has sufficient capacity to hold volume of all tanks with tank containment area and single liner under containment area with leachate collections and removal system, and groundwater monitoring	5
(e) same as (d) except: double liner under containment area with functioning leachate collection and removal system	3
Tank is above ground, and inside or under maintained intact structure that provides protection from precipitation so neither runoff nor leachate would be generated from any material released from tank	0

2b "Net Precipitation" -- use the "Net Precipitation Factor Values Map" to determine the value for the area where the spill has occurred (see map page).

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2c "Depth to Aquifer" -- use the table "Depth to Aquifer Factor Values" to assign a value for this blank.

TABLE: Depth to Aquifer Factor Values

Depth to aquifer (feet)	Assigned Value
Less than or equal to 25 feet	5
Greater than 25 but less than 250 feet	3
Greater than 250 feet	1

2d "Travel Time" -- If the depth to the aquifer is 10 feet or less, assign a value of 35. If the layers at the spill site are Karst, assign a value of 35. Check the Karst Map (on map page) to see if your spill site is in a Karst zone.
If your site does not fit those two situations, then use the tables "Hydraulic Conductivity of Geologic Materials" and "Travel Time Factor Values" to determine your result.

TABLE: Hydraulic Conductivity of Geologic Materials

Type of material	Assigned hydraulic conductivity (cm/sec)
CLAY: low permeability till; shale; unfractured metamorphic and igneous rocks	10^{-8}
SILT: loesses; silty clays; sediments that are predominantly silts; moderately permeable till; low permeability limestones and dolomites (no karst); low permeability sandstone; low permeability fractured igneous and metamorphic rocks	10^{-6}
SAND: sandy silts; sediments that are predominantly sand; highly permeable till; peat; moderately permeable limestones and dolomites (no karst); moderately permeable sandstone; moderately permeable fractured igneous and metamorphic rocks	10^{-4}
GRAVEL: Clean sand; highly permeable fractured igneous and metamorphic rocks; permeable basalt; karst limestones and dolomites	10^{-2}

TABLE: Travel Time Factor Values

	Thickness of lowest hydraulic conductivity layer(s) (feet)			
Hydraulic conductivity (cm/sec)	Greater than 3 to 5	Greater than 5 to 100	Greater than 100 to 500	Greater than 500
Greater than or equal to 10^{-3}	35	35	35	25
Less than 10^{-3} to 10^{-5}	35	25	15	15
Less than 10^{-5} to 10^{-7}	15	15	5	5
Less than 10^{-7}	5	5	1	1

2e "Potential to Release" -- add the values for net precipitation, depth to aquifer, and travel time (2b + 2c + 2d), then multiply by the containment value (x 2a). Enter the final result in 2e, determine step 3, and continue on to part II.

Step 3 Pick which of line 1 or line 2e has the greater value, then enter this amount on the scoresheet.

Part II - Waste Characteristics:

Step 4 "Toxicity/Mobility" -- Determine how poisonous the contaminant is and how easily it moves through the groundwater. Use the "Toxicity Factor Evaluation" table to get a value for Human Chronic Toxicity for the hazardous substance. The mobility factor will be 0.002. Use these two values and the table "Toxicity/Mobility Factor Values" to determine the value to write in Step 4.

TABLE: Toxicity Factor Evaluation
Chronic Toxicity (Human)

Reference Dose (RfD) (mg/kg-day)	Assigned Value
Rfd < 0.0005	10,000
0.0005 ≤ RfD < 0.005	1,000
0.005 ≤ RfD < 0.05	100
0.05 ≤ RfD < 0.5	10
0.5 ≤ RfD	1
RfD not available	0

TABLE: Toxicity/Mobility Factor Values

Mobility factor value	Toxicity factor value					
	10,000	1,000	100	10	1	0
1.0	10,000	1,000	100	10	1	0
0.2	2,000	200	20	2	0.2	0
0.01	100	10	1	0.1	0.01	0
0.002	20	2	0.2	0.02	0.002	0
0.0001	1	0.1	0.01	0.001	1×10^{-4}	0
2×10^{-5}	0.2	0.02	0.002	2×10^{-4}	2×10^{-5}	0
2×10^{-7}	0.002	2×10^{-4}	2×10^{-5}	2×10^{-6}	2×10^{-7}	0
2×10^{-9}	2×10^{-5}	2×10^{-6}	2×10^{-7}	2×10^{-8}	2×10^{-9}	0

Step 5 "Hazardous Waste Quantity" -- The quantity to write is the number of pounds of contaminant spilled.

Step 6 "Waste Characteristics" -- Multiply the values from Step 4 and Step 5, then use the table "Waste Characteristics Factor Category Values" to determine the value to write in Step 6. Then continue to Part III.

TABLE: Waste Characteristics Factor Category Values

Waste characteristics product	Assigned value
0	0
Greater than 0 to less than 10	1
10 to less than 1×10^2	2
1×10^2 to less than 1×10^3	3
1×10^3 to less than 1×10^4	6
1×10^4 to less than 1×10^5	10
1×10^5 to less than 1×10^6	18
1×10^6 to less than 1×10^7	32
1×10^7 to less than 1×10^8	56
1×10^8 to less than 1×10^9	100
1×10^9 to less than 1×10^{10}	180
1×10^{10} to less than 1×10^{11}	320
1×10^{11} to less than 1×10^{12}	560
1×10^{12}	1,000

Part III - "Targets"

In this section you evaluate the number of people and uses that may be affected by contaminated water.

Step 7 "Nearest Well" -- You will use the "Nearest Well Factor Values" table to find the proper value. Use a 4-mile target distance limit from the source of contamination in all directions.

-- If the contaminant was directly observed to be released at the well, at more than the contaminant reference dose provided in the lab analysis, then use the Level I concentration value.

-- If the contamination was directly observed to be released at the well, at less than the reference dose, then use the Level II value.

-- If the contaminant was not observed to be released at the well, then use the value corresponding to the distance of the nearest well to the contaminant release.

TABLE: Nearest Well Factor Values

Distance from source (miles)	Assigned value
Level I concentrations	50
Level II concentrations	45
0 to 1/4	20
Greater than 1/4 to 1/2	18
Greater than 1/2 to 1	9
Greater than 1 to 2	5
Greater than 2 to 3	3
Greater than 3 to 4	2
Greater than 4	0

Step 8 "Population" -- You must determine the number of people using the well for drinking water within the 4-mile target distance.

8a "Level I Concentration" -- If a well fits the Level I description (direct observation of leak), multiply the number of people regularly using that well by 10, and then write the answer in 8a.

8b "Level II Concentration" -- If a well fits the Level II description (direct observation of leak), list the number of people normally using the well in 8b.

8c "Potential Contamination" -- If there are wells not fitting Level I or Level II (no direct observation), use the "Distance-Weighted Population" table to compute a value. You will have to determine the number of people using wells in each distance category for either "Karst" or "Other Than Karst" topography. You can list the values from the table for each distance category, then add the six values together.

TABLE: Distance Weighted Population Values

Distance Category (miles)	Number of people within the distance category												
	0	1 to 10	11 to 30	31 to 100	101 to 300	301 to 1000	1001 to 3000	3001 to 10000	10001 to 30000	30001 to 100000	100001 to 300000	300001 to 1000000	1000001 to 3000000
Other than Karst													
0 to 1/4	0	4	17	53	164	522	1633	5214	16325	52137	163246	521360	1632455
1/4 to 1/2	0	2	11	33	102	324	1013	3233	10122	32325	101213	323243	1012122
1/2 to 1	0	1	5	17	52	167	523	1669	5224	16684	52239	166835	522385
1 to 2	0	0.7	3	10	30	94	294	939	2939	9385	29384	93845	293842
2 to 3	0	0.5	2	7	21	68	212	678	2122	6778	21222	67777	212219
3 to 4	0	0.3	1	4	13	42	131	417	1306	4171	13060	41709	130596
Karst													
0 to 1/4	0	4	17	53	164	522	1633	5214	16325	52137	163246	521360	1632455
1/4 to 1/2	0	2	11	33	102	324	1013	3233	10122	32325	101213	323243	1012122
1/2 to 1	0	2	9	26	82	261	817	2607	8163	26068	81623	260680	816227
1 to 2	0	2	9	26	82	261	817	2607	8163	26068	81623	260680	816227
2 to 3	0	2	9	26	82	261	817	2607	8163	26068	81623	260680	816227
3 to 4	0	2	9	26	82	261	817	2607	8163	26068	81623	260680	816227

8d "Population" -- Add lines 8a + 8b + 8c together and write your answer in 8d on the scoresheet.

Step 9 "Resources" -- From the list below choose the highest resource value that applies to the contaminated aquifer:

5 -- if the water from any well in the target distance is used for irrigating commercial crops, watering commercial livestock, supplying commercial agriculture, supplying water recreation area, or could be used for drinking water.

0 -- if none of the above applies.

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Step 10 "Wellhead Protection Area" -- Choose the highest value from the list below that applies to the contaminated aquifer:

20 -- if a well with a containment value (from table: Containment Factor Values) greater than 0 is at least partly in a Wellhead Protection Area or observed contamination is at least partly in a Wellhead Protection Area.

5 -- if neither of the above applies, and if the aquifer within the 4-mile target distance is in a Wellhead Protection Area.

0 -- if none of the above applies

Step 11 "Targets" -- add lines 7 + 8d + 9 + 10 together and write the answer in line 11.

Part IV: Groundwater Migration Score for Aquifer

Find the overall score (S_{gw}) by multiplying "Likelihood of Release" (LR) (Step 3) times "Waste Characteristics" (WC) (Step 6) times "Targets" (T) (Step 11), then divide by 82,500 to get your answer for the aquifer score.

Use the formula:

$$S_{gw} = \frac{LR \times WC \times T}{82{,}500}$$

HRS Score Instructions

Find the Final Hazard Ranking System site score (S) for your contaminated area using the following formula:

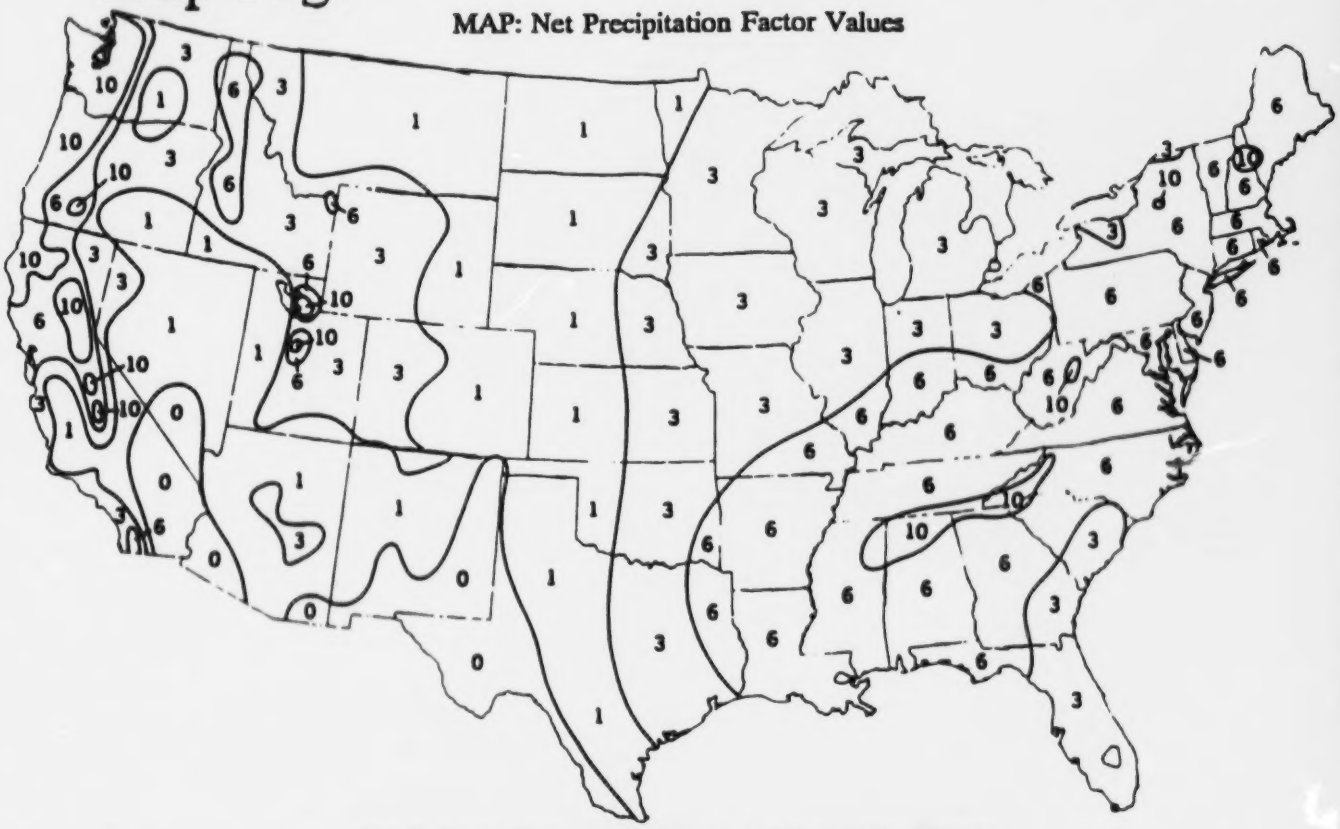
$$S = \sqrt{\frac{(S_{gw}^2 + S_{sw}^2 + S_s^2 + S_a^2)}{4}}$$

S_{gw}=groundwater score; S_{sw}=surface water score; S_s=soil score; and S_a=air score.

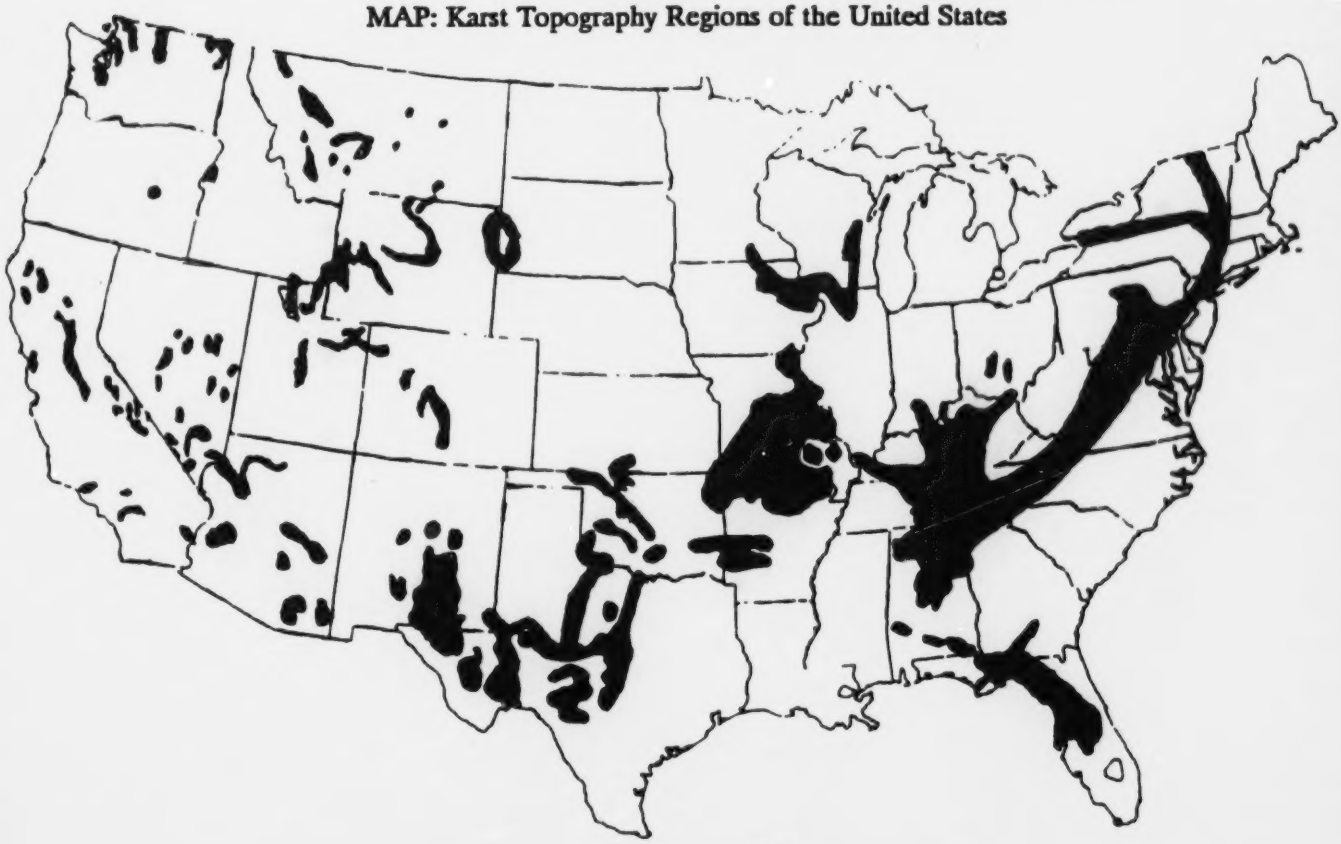
Compare the HRS score for your site with other sites evaluated in the class. Compare these sites with real ones listed in the National Priority List (NPL)

Map Page

MAP: Net Precipitation Factor Values



MAP: Karst Topography Regions of the United States



Definitions:

Aquifer: Underground porous rock structure that contains water.

CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act of 1980.

Contaminant: Unwanted matter.

Hazardous substance: CERCLA defined hazardous substances, pollutants, and contaminants.

HRS: Hazard Ranking System

HRS "factor": Primary rating elements of the HRS.

HRS "factor category": Set of HRS factors (that is, likelihood of release, waste characteristic, targets).

HRS "migration pathways": HRS groundwater, surface water, and air movement routes.

HRS "site score": Composite of the four HRS pathway scores.

Hydrologic Conductivity: The rate of movement of fluids through a porous solid, measured in centimeters per second.

Karst: Terrain with characteristics of relief and drainage arising from a high degree of rock solubility in natural water. The majority of karst occurs in limestones, but karst may also form in dolomite, gypsum, and salt deposits. Features associated with karst terrains typically include irregular surface, sinkholes, vertical shafts, abrupt ridges, caverns, abundant springs, and/or disappearing streams.

Reference dose (RfD): Estimate of a daily exposure level of a substance to a human population below which adverse noncancer health effects are not anticipated. (unit: milligrams of toxicant per kilogram body weight per day).

Site: Area(s) where a hazardous substance has been deposited, stored, disposed, or placed, or has otherwise come to be located. Such areas may include multiple sources and may include the area between sources.

Source: Any area where a hazardous substance has been deposited, stored, disposed, or placed, plus those soils that have become contaminated from migration of a hazardous substance. Sources do not include those volumes of air, groundwater, surface water, or surface water sediments that have become contaminated by migration.

Target distance limit: Maximum distance over which targets for the site are evaluated. The target distance limit varies by HRS pathway.

Wellhead Protection Area: the surface and subsurface areas surrounding a water well supplying a public water system, and through which contaminants are reasonably likely to move toward and reach such water well

National Priorities List Examples

as of June 1992

The Environmental Protection Agency (EPA) began after the enactment of the CERCLA (Superfund) legislation in 1980 to evaluate hazardous waste sites across the U.S. There was a need to identify the most dangerous sites so that cleanup could begin. The National Priorities List (updated in 1992) has 1,067 sites around the country, plus 28 federally owned sites. Not all states have ranked sites.

NPL Rank	HRS Score	Site Name	State	Location
1	75.60	Lipari Landfill	NJ	Pitman
50	58.54	Omega Hill North Landfill	WI	Germantown
100	57.80	Arkansas City Dump	KS	Arkansas City
150	52.58	Ringwood Mines/Landfill	NJ	Ringwood
200	50.19	Ewan Property	NJ	Shemong
250	47.49	Master Disposal Service Landfill	WI	Brookfield
300	45.91	Culpeper Wood Preservers	VA	Culpeper
350	43.75	Arrowhead Refinery Co.	MN	Hermantown
400	42.33	Wayne Waste Oil	IN	Columbia City
449	41.44	Hooker Chemical	NY	Hicksville
499	39.87	Cannon Engineering Corp.	MA	Bridgewater
549	38.17	Chem Central	MI	Wyoming
599	37.52	Sangamo/Twelve-Mile/Hartwell PCB	SC	Pickens
648	35.72	Stoughton City Landfill	WI	Stoughton
698	35.34	29th & Mead Ground Water Contamination	KS	Wichita
748	34.21	Adams County Landfills 2 & 3	IL	Quincy
798	33.71	Koopers Co. Inc.	CA	Oroville
848	32.65	Tomah Fairground	WI	Tomah
898	31.86	Advanced Micro Devices	CA	Sunnyvale
947	30.78	Halby Chemical Co.	DE	New Castle
997	29.78	Republic Steel Corp. Quarry	OH	Elyria
1045	28.90	10th Street Site	NE	Columbus
1067	28.50	White Chemical Corp.	NJ	Newark/Essex

Hazard Ranking System (HRS) Worksheet

(Student Worksheet)

Name:_____

Date:_____

Site:_____

Contaminating Chemical:_____

Table -- Groundwater Migration Pathway Scoresheet

Factor categories and factors	Maximum value	Value assigned
Likelihood of Release to an Aquifer:		
1. Observed Release	550	_____
2. Potential to Release:		
2a. Containment	10	_____
2b. Net Precipitation	10	_____
2c. Depth to Aquifer	5	_____
2d. Travel Time	35	_____
2e. Potential to Release [lines 2a(2b + 2c + 2d)]	500	_____
3. Likelihood of Release (higher of lines 1 or 2e)	550	_____
Waste Characteristics:		
4. Toxicity/Mobility	no limit	_____
5. Hazardous Waste Quantity	no limit	_____
6. Waste Characteristics	100	_____
Targets:		
7 Nearest Well	50	_____
8. Population:		
8a Level I Concentrations	no limit	_____
8b. Level II Concentrations	no limit	_____
8c. Potential Contamination	no limit	_____
8d. Population (lines 8a + 8b + 8c)	no limit	_____
9. Resources	5	_____
10. Wellhead Protection Area	20	_____
11. Targets (lines 7 + 8d + 9 + 10)	no limit	_____
Groundwater Migration Score for Aquifer		
Aquifer Score [(lines 3 x 6 x 11)/82,500]	100	_____

Distance Category (K or OTK)

0 -- 1/4 mile = _____

1/4 -- 1/2 mile = +_____

1/2 -- 1 mile = +_____

1 -- 2 miles = +_____

2 -- 3 miles = +_____

3 -- 4 miles = +_____

Total ===== _____ / 10 = _____ (8c)

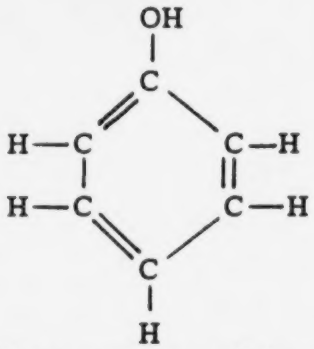
Mendeleev Analysis Associates
Lab Report: Chemical Analysis

The compound PHENOL was identified as the leaking material from the storage tank at the site. Phenol is also called: Baker's P & S liquid/ointment; carbolic acid, phenic acid.

Chemical Formula: C_6H_6O

Formula Weight: 94.11 amu

Structural Formula:



Appearance/Color: White crystals or light pink liquid which slowly turns brown on exposure to air, sweet tarry odor.

Physical Properties:
Boiling Point: 181.7° Celsius
Melting Point: 43.0° Celsius
Log K_{ow}: 1.47
Solubility in Water: 82,000 mg/L @ 15°C
93,000 mg/L @ 25°C

RCRA Waste Number: U188

Reference Dose: 0.6 mg/kg-day

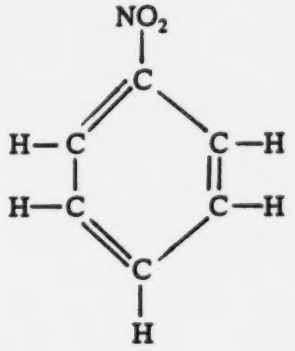
Common Uses for Phenol: Ingredient of antiseptic, disinfectants, pharmaceuticals, dyes, indicators, slimicide, epoxy resins, nylons, salicylic acids, phenolphthalein, lab reagent.

Mendeleev Analysis Associates
Lab Report: Chemical Analysis

The compound NITROBENZENE was identified as the leaking material from the storage tank at the site. Nitrobenzene is also called : essence of mirbane, oil of bitter almonds.

Chemical Formula: $C_6H_5NO_2$

Structural Formula:



Appearance/Color: Light yellow to brown, oily liquid with an almond or shoe polish odor.

Physical Properties:
Boiling Point: 210.8 °C
Melting Point: 5.7 °C
Log K_{ow}: 1.84

RCRA Waste Number: U169, UN 1662

Reference Dose: 0.0005 mg/kg-day

Common Uses for Nitrobenzene: solvent for cellulose ethers, ingredient of metal polishes and shoe polishes, and manufacture of drugs and photographic chemicals.

Descartes, Inc. Site Report Summary

Site Identification: Acme Chemical
12 Acme Road, Perry, Florida (closest city: Tallahassee)
Longitude: 83.5° West, Latitude: 30° North

Site Information: The plant was involved in the production of pharmaceutical ingredients up to the 1960s, and occupies 18 acres on the northwest side of town.

Structures: Several empty, unused warehouses, roads, and well monitoring sheds, complete perimeter fence, monitoring wells for all storage tanks, pavement covering underground storage tanks

Geological Findings: Depth to aquifer 30 feet
Soil material: Sandy soil with limestone base.
Thickness of lowest conductivity layer 8 feet

Contaminant Observation:

Monitoring equipment revealed a reduction in volume in underground storage tank #21 equivalent to about 100 pounds of liquid released. The tank volume has stabilized. It is unknown whether the liquid reached the aquifer.

The liquid was stored in a regularly monitored buried tank 20 feet deep, under a maintained nonpermeable asphalt cover. The liquid was found to extend about 3000 feet from the source at the farthest point from the tank.

Tank #21 is located in the southwestern quadrant of the factory property.

Surrounding Area:

The chemical plant is located in an industrial zone with no surface water or fisheries or sensitive environments within several miles. The topography is relatively level.

The nearby residential areas are rural with no people living within a mile of the facility. The nearest water well is just over one half mile away from the leaking tank. All wells are to be considered within the Wellhead Protection Areas.

Well Data:

Well #	Distance from source	Use
14-203	0.6 miles	Drinking water for family of 6
21-11	0.6 miles	Irrigation for crops
107-25	1.2 miles	Water for dairy farm
02-578	1.4 miles	Drinking water for family of 5
11-37	2.3 miles	Drinking water for 21 residents
35-254	2.7 miles	Drinking water for 49 residents
35-354	3.1 miles	Drinking water for 77 residents

Supplemental Report: Site Scores

The analysts performing the site scores for soil, air, and surface water have reported the following results:

Soil	0	
Air	0	Due to the absence of contact between the liquid and air
Surface water	0	Due to the absence of rivers, lakes, and fisheries nearby

Descartes, Inc. Site Report Summary

Site Identification: Tristate Chemical
211 Central Blvd., Scranton, Pennsylvania
Longitude: 76° North, Latitude: 41.5° West

Site Information: The plant was involved in the production of manufacturing ingredients up to the 1960s, and occupies 12 acres on the northeast side of town.

Structures: Several empty, unused warehouses, roads, and well monitoring sheds, complete perimeter fence, monitoring wells for all storage tanks, pavement covering underground storage tanks

Geological Findings: Depth to aquifer 280 feet
Soil material: clay soil with a shale base
Thickness of lowest conductivity layer 18 feet

Contaminant Observation:

Monitoring equipment revealed a reduction in volume in underground storage tank #21 equivalent to about 100 pounds of liquid released. The tank volume has stabilized. It is unknown whether the liquid reached the aquifer.

The liquid was stored in a regularly monitored buried tank 18 feet deep, under a maintained nonpermeable asphalt cover. The liquid was found to extend about 2500 feet from the source at the farthest point from the tank. Tank #21 is located in the southwestern quadrant of the factory property.

Surrounding Area:

The chemical plant is located in an industrial zone with no surface water or fisheries or sensitive environments within several miles. The topography is relatively level.

The nearby residential areas are urban with 275,000 people living within a mile of the facility. The nearest water well is just over one half mile away from the leaking tank. All wells are to be considered within Wellhead Protection Areas.

Well Data:

Well #	Distance from source	Use
14-203	0.37 miles	Drinking water for 109,700 people
21-11	0.51 miles	Drinking water for 98,400 people
107-25	1.12 miles	Drinking water for 49,100 people
02-578	1.78 miles	Drinking water for 22,000 people
11-37	2.6 miles	Drinking water for 25,900 people
35-254	3.4 miles	Irrigating commercial crops
35-354	3.7 miles	Drinking water for 500 people

Supplemental Report: Site Scores

The analysts performing the site scores for soil, air, and surface water have reported the following results:

Soil	0.02272 (phenol), 0.13636 (nitrobenzene)	
Air	0	Due to the absence of contact between the liquid and air
Surface water	0	Due to the absence of rivers, lakes, and fisheries nearby

Site Identification: Color Corporation
1212 Route 66, Belden, North Dakota
Longitude: 100° West, Latitude: 47° North

Site Information: The plant was involved in the production of dyes up to the 1960s, and occupies 21 acres on the southwest side of town.

Structures: Several empty, unused warehouses, roads, and well monitoring sheds, complete perimeter fence, monitoring wells for all storage tanks, pavement covering underground storage tanks

Geological Findings: Depth to aquifer 87 feet
Soil material: glacial deposits of sand and sandy silt, over a base of sandstone
Thickness of lowest conductivity layer 22 feet

Contaminant Observation:

Monitoring equipment revealed a reduction in volume in underground storage tank #21 equivalent to about 100 pounds of liquid released. The tank volume has stabilized. It is unknown whether the liquid reached the aquifer.

The liquid was stored in a regularly monitored buried tank 18 feet deep, under a maintained nonpermeable asphalt cover. The liquid was found to extend about 2800 feet from the source at the farthest point from the tank.

Tank #21 is located in the southwestern quadrant of the factory property.

Surrounding Area:

The chemical plant is located in an industrial zone with no surface water or fisheries or sensitive environments within several miles. The topography is relatively level.

The nearby residential areas are rural with no people living within a mile of the facility. The nearest water well is just over one half mile away from the leaking tank. All wells are to be considered to Wellhead Protection Areas.

Well Data:

Well #	Distance from source	Use
14-203	0.8 miles	Drinking water for family of 7
21-11	0.9 miles	Irrigation for crops
107-25	1.7 miles	Water for farm
02-578	1.8 miles	Drinking water for family of 4
11-37	2.1 miles	Drinking water for 43 residents
35-254	2.4 miles	Drinking water for 79 residents
35-354	3.3 miles	Drinking water for 102 people

Supplemental Report: Site Scores

The analysts performing the site scores for soil, air, and surface water have reported the following results:

Soil	0	
Air	0	Due to the absence of contact between the liquid and air
Surface water	0	Due to the absence of rivers, lakes, and fisheries nearby

Site Identification: LabChem
4356 State Road 29, Las Vegas, Navada
Longitude: 115° West, Latitude: 36° North

Site Information: The plant was involved in the production of analysis chemicals up to the 1960s, and occupies 13 acres on the northeast side of town.

Structures: Several empty, unused warehouses, roads, and well monitoring sheds, complete perimeter fence, monitoring wells for all storage tanks, pavement covering underground storage tanks

Geological Findings: Depth to aquifer 200 feet
Soil material: gravel deposits over an igneous basalt base
Thickness of lowest conductivity layer 6 feet

Contaminant Observation:

Monitoring equipment revealed a reduction in volume in underground storage tank #21 equivalent to about 100 pounds of liquid released. The tank volume has stabilized. It is unknown whether the liquid reached the aquifer.

The liquid was stored in a regularly monitored buried tank 16 feet deep, under a maintained nonpermeable asphalt cover. The liquid was found to extend about 2900 feet from the source at the farthest point from the tank.

Tank #21 is located in the southwestern quadrant of the factory property.

Surrounding Area:

The chemical plant is located in an industrial zone with no surface water or fisheries or sensitive environments within several miles. The topography is relatively level.

The nearby residential areas are rural with 275,000 people living within a mile of the facility. The nearest water well is just over one half mile away from the leaking tank. All wells should be considered within Wellhead Protection Areas

Well Data:

Well #	Distance from source	Use
14-203	0.7 miles	Drinking water for 99,800 people
21-11	0.8 miles	Drinking water for 112,200 people
107-25	1.24 miles	Drinking water for 51,700 people
02-578	1.58 miles	Drinking water for 20,700 people
11-37	2.67 miles	Drinking water for 29,300 people
35-254	2.7 miles	Feed crop irrigation
35-354	3.4 miles	Drinking water for 14,000 people

Supplemental Report: Site Scores

The analysts performing the site scores for soil, air, and surface water have reported the following results:

Soil	0.02272 (phenol), 0.13636 (nitrobenzene)	
Air	0	Due to the absence of contact between the liquid and air
Surface water	0	Due to the absence of rivers, lakes, and fisheries nearby